GUIDANCE SYSTEM IN MISSILES

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WHAT IS A MISSILE?

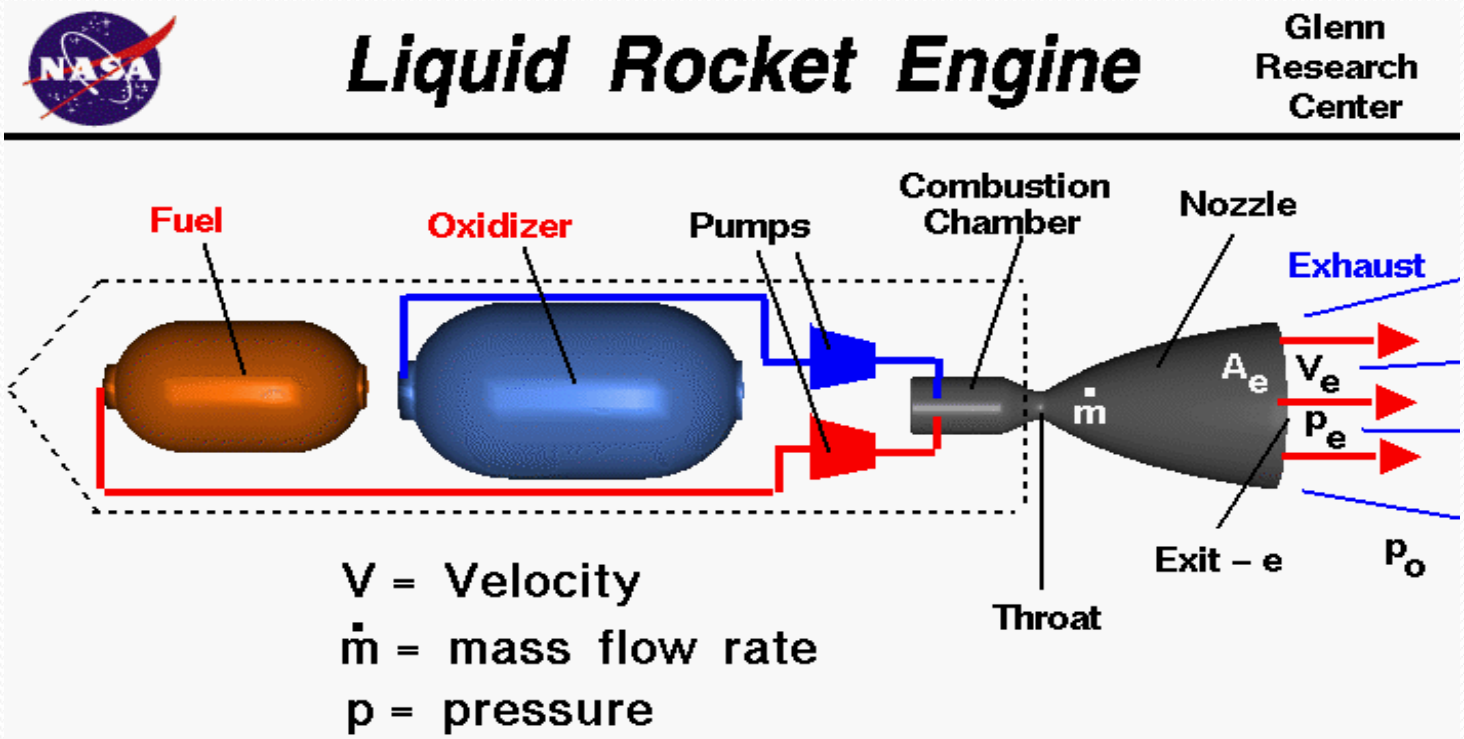
- Basically any object thrown at a target with the aim of hitting it is a **missile**. Thus, a stone thrown at a bird is a missile.
- The bird, by using its power of reasoning may evade the missile (the stone) by moving either to the Left, right, top or bottom with respect to the flight path (trajectory) of the missile. Thus, the missile in this case has been ineffective in its objective of hitting the bird (the target.
- Now, if the stone too is imparted with some intelligence and quick response to move with respect to the bird, to overcome aiming errors and the bird's evasive actions and hit it accurately, the stone now becomes a **guided missile.**

kill two birds with one stone

- Hence, in modern era, a **missile** is a self-propelled precision-guided munition system, as opposed to an unguided self-propelled munition, referred to as a rocket.

- The incorporation of energy source in a missile to provide the required force for its movement (propulsion) intelligence to go in the correct direction (guidance) and effective maneuvering (control) are mainly the technologies of guided missiles. They help in making a missile specific to a target, that is, they determine the size, range and state of motion of a missile.

HOW DOES A MISSILE WORK?

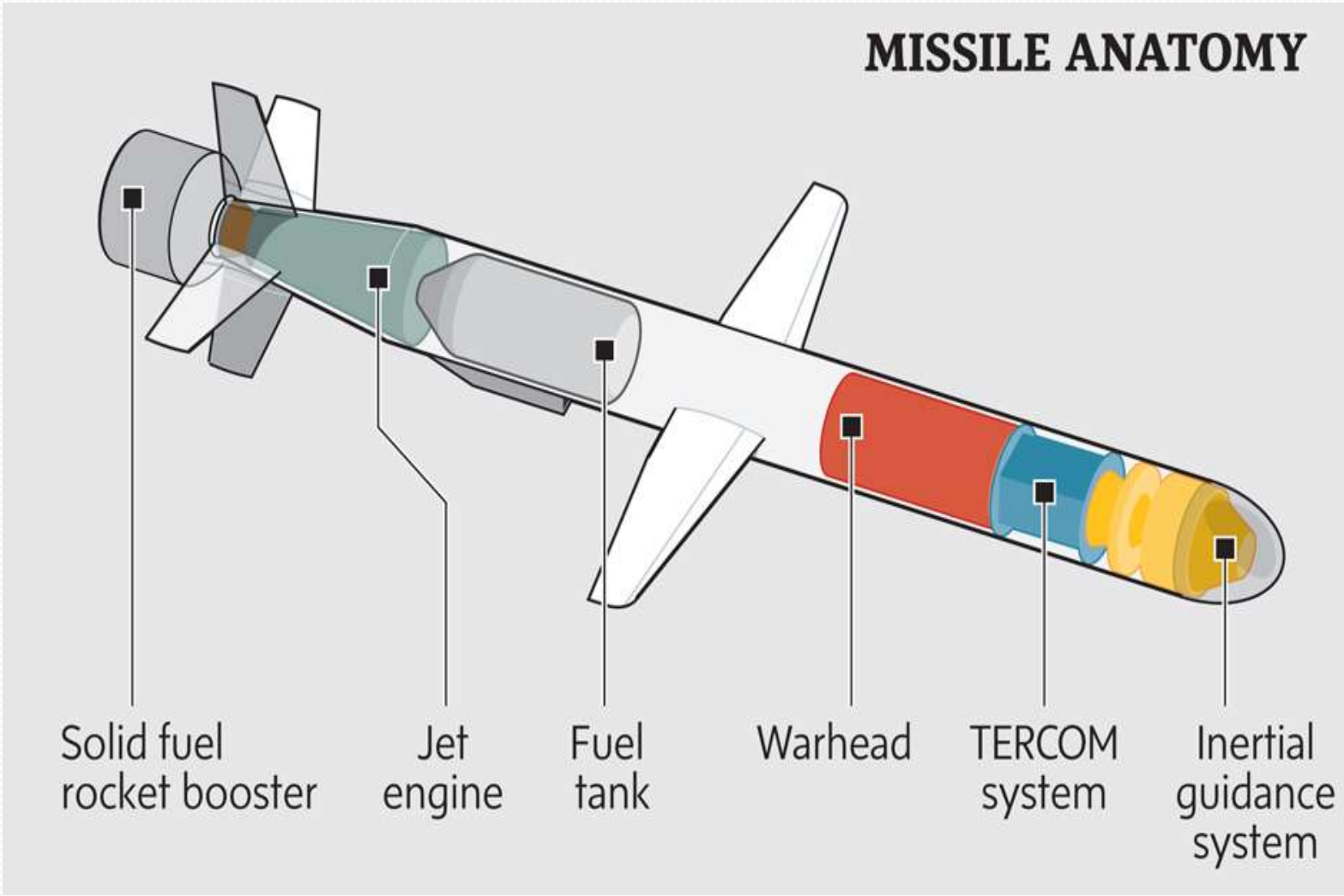


$$\text{Thrust} = \quad F = \dot{m}\, V_e + (p_e - p_0)\, A_e$$

COMPONENTS IN A MISSILE

There are four main components in a missile:

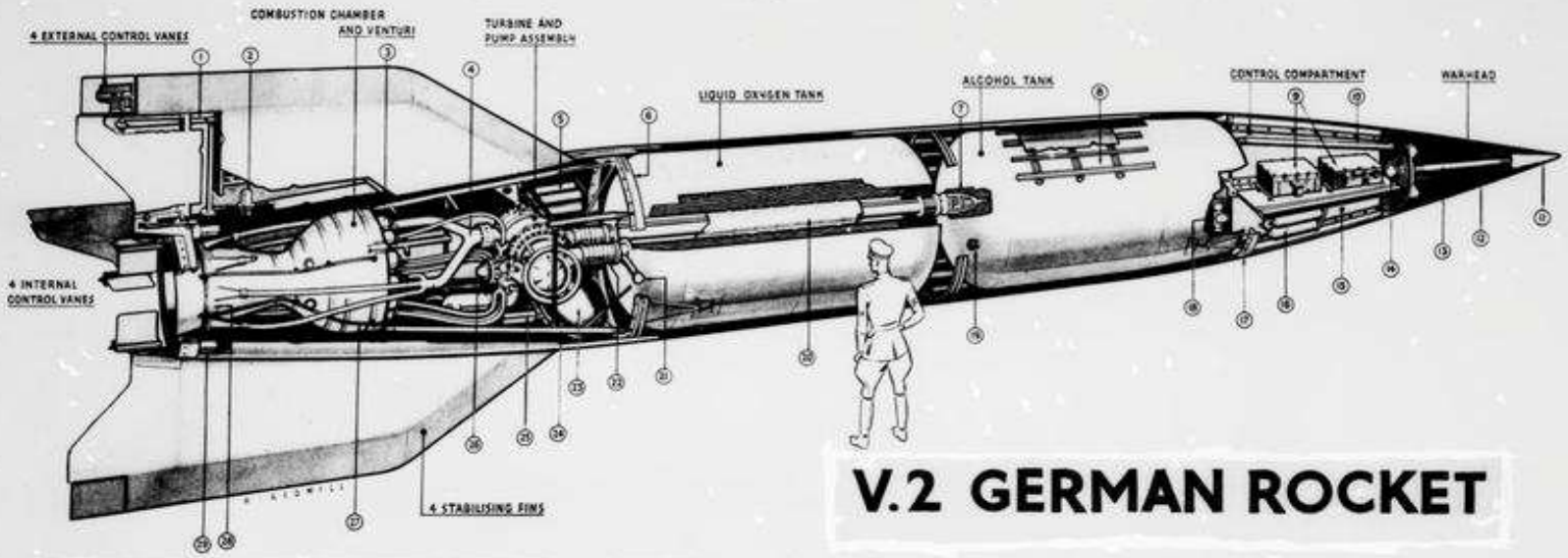
- WARHEAD
- PROPULSION SYSTEM
- GUIDANCE SYSTEM
- CONTROL SYSTEM


MISSILE ANATOMY
Solid fuel rocket booster
Jet engine
Fuel tank
Warhead
TERCOM system
Inertial guidance system

HISTORY OF MISSILES

- Looking back into the history of rockets and guided missiles, we find that rockets were used in China and India around **1000 AD** for fireworks as well as for war purposes.
- During the **18th century**, unguided rocket propelled missiles were used by Hyder Ali and his son Tipu Sultan against the British.
- The advanced phase in the history of guided missiles began during the **World War II** with the use of ***V1*** and ***V2*** missiles by Hitler's Nazi Germany.

V1 Rocket – The Flying Bomb (Also known as buzz bomb)



V.2 GERMAN ROCKET

1 CHAIN DRIVE TO EXTERNAL CONTROL VALVES.

2 ELECTRIC MOTOR.

3 BURNER CUPS.

4 ALCOHOL SUPPLY FROM PUMP.

5 AIR BOTTLES.

6 REAR JOINT RING AND STRONG POINT FOR TRANSPORT.

7 SERVO-OPERATE ALCOHOL OUTLET VALVE.

8 ROCKET SHELL CONSTRUCTION.

9 RADIO EQUIPMENT.

10 PIPE LEADING FROM ALCOHOL TANK TO WARHEAD.

11 NOSE PROBABLY FITTED WITH NOSE SWITCH OR OTHER DEVICE FOR OPERATING WARHEAD FUZE.

12 CONDUIT CARRYING WIRES TO NOSE OR WARHEAD.

13 CENTRAL EXPLORER TUBE.

14 ELECTRIC FUZE FOR WARHEAD.

15 PLYWOOD FRAME.

16 NITROGEN BOTTLES.

17 FRONT JOINT RING AND STRONG POINT FOR TRANSPORT.

18 PITCH AND AZIMUTH GYROS.

19 ALCOHOL FILLING POINT.

20 DOUBLE WALLED ALCOHOL DELIVERY PIPE TO PUMP.

21 OXYGEN FILLING POINT.

22 CONCERTINA CONNECTIONS.

23 HYDROGEN PEROXIDE TANK.

24 TUBULAR FRAME HOLDING TURBINE AND PUMP ASSEMBLY.

25 PERMANGANATE TANK (GAS GENERATOR UNIT BEHIND THIS TANK).

26 OXYGEN DISTRIBUTOR FROM PUMP.

27 ALCOHOL PIPES FOR SUBSIDIARY COOLING.

28 ALCOHOL INLET TO DOUBLE WALL.

29 ELECTRO HYDRAULIC SERVO MOTORS.

CLASSIFICATION OF MISSILES

On the method of launching, the missiles are classified as:

- Surface-to-surface-missiles (SSM)
- Surface-to-air missiles (SAM)
- Air-to-air missiles (AAM)
- Air-to-surface missiles (ASM

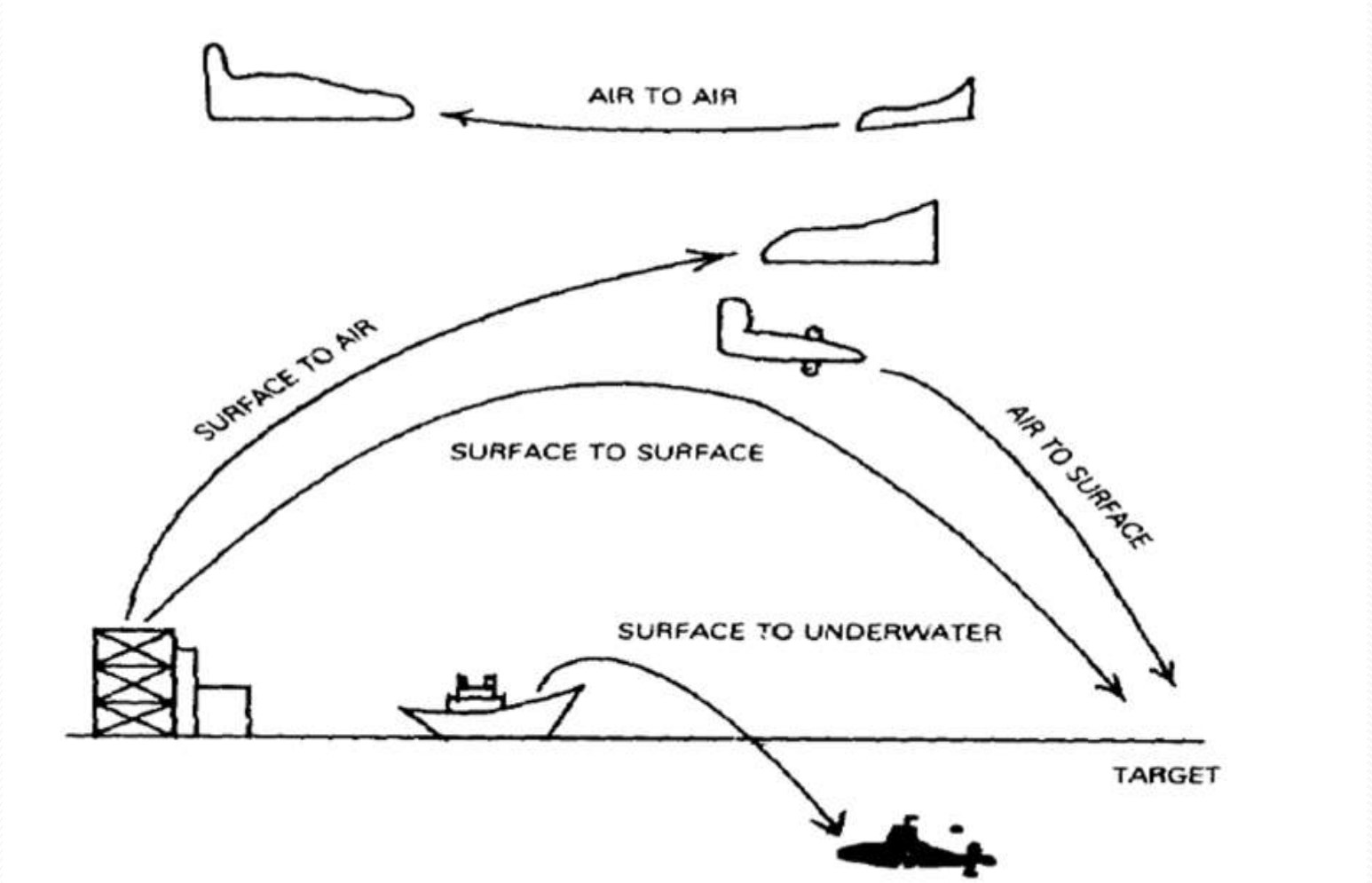


Diagram to enunciate the classification of missiles

On the basis of range, missiles can also be classified as:

- Short-range missiles
- Medium-range ballistic missiles (MRBM)
- Intermediate range ballistic missiles(IRBM)
- Intercontinental or long-range ballistic missiles(ICBM).

GUIDANCE SYSTEM IN MISSILES

The guidance system in missiles consists of two units:

- Electronic unit
- Mechanical unit

The purpose of electronic unit is to anticipate the location of target, compare it with LOS(Line of Sight) and send the necessary command to the mechanical unit.

The purpose of mechanical unit is to act in the way, commanded by EU and keep the missile stable during the flight.

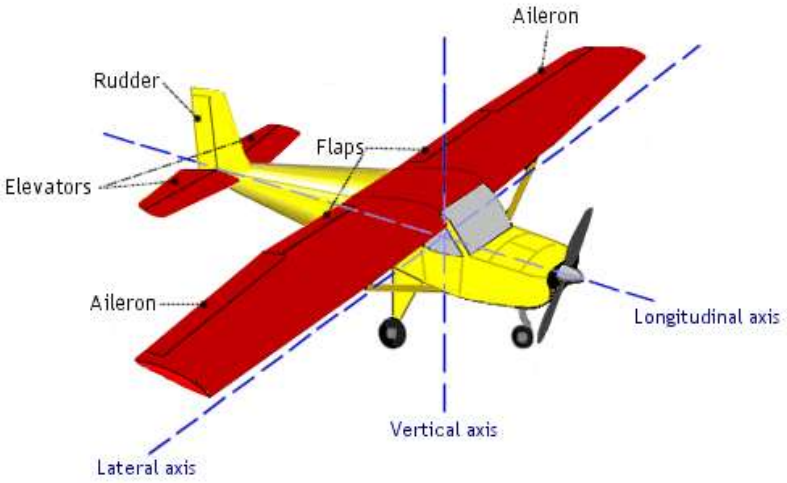
GUIDANCE WITHOUT ELECTRONICS GERMAN V1 AND V2 ROCKETS

- The electronic systems were not that advanced during the Second World War(1939 - 1945) and all the planes were flown manually.
- To guide a so called “FLYING BOMB” by the Germans was an accolade of fine Mechanical Engineering Masterpiece.
- To understand how these rockets were guided, we need to make ourselves clear the concept of:

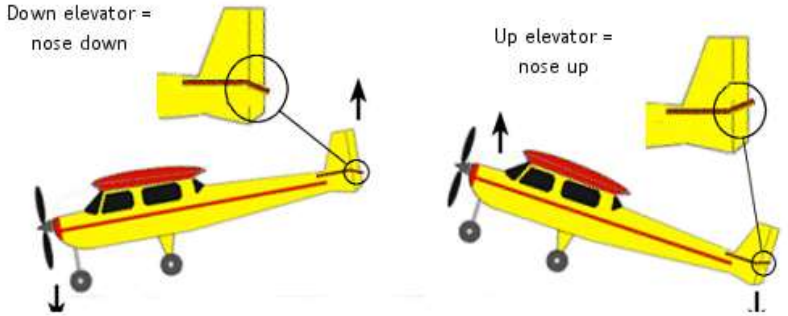
  Ailerons

  Elevator

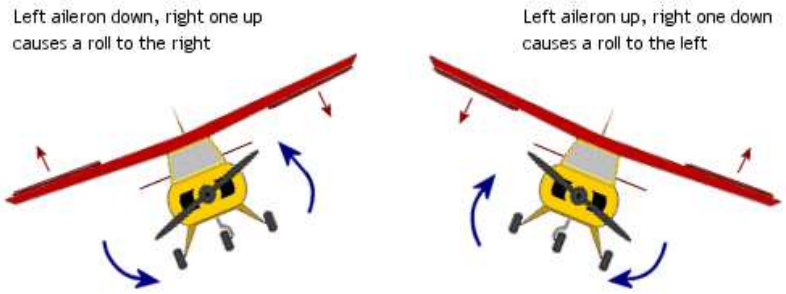
  Rudder



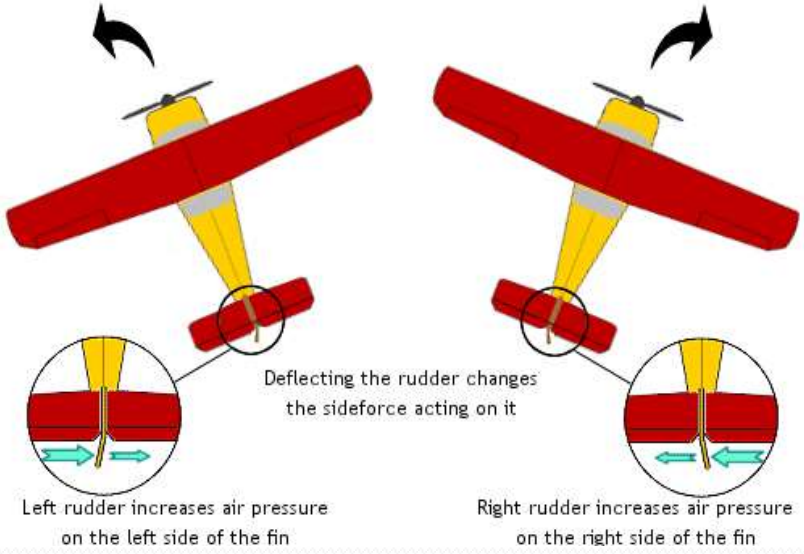
Elevators

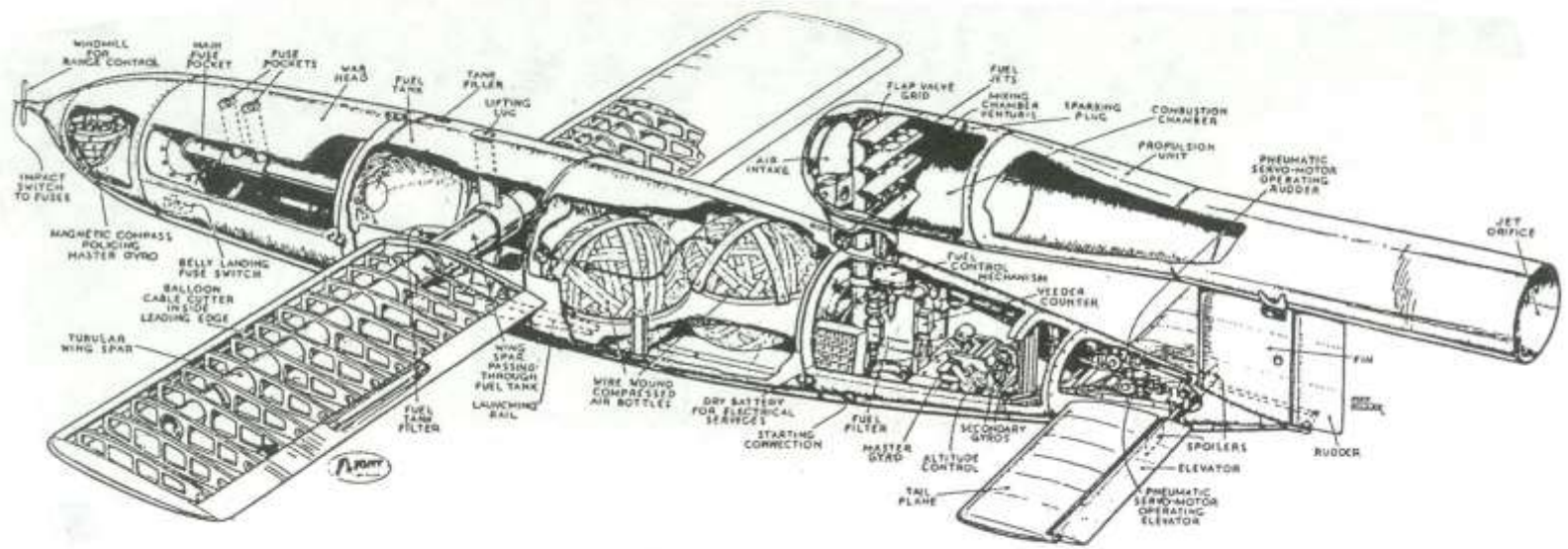


Ailerons

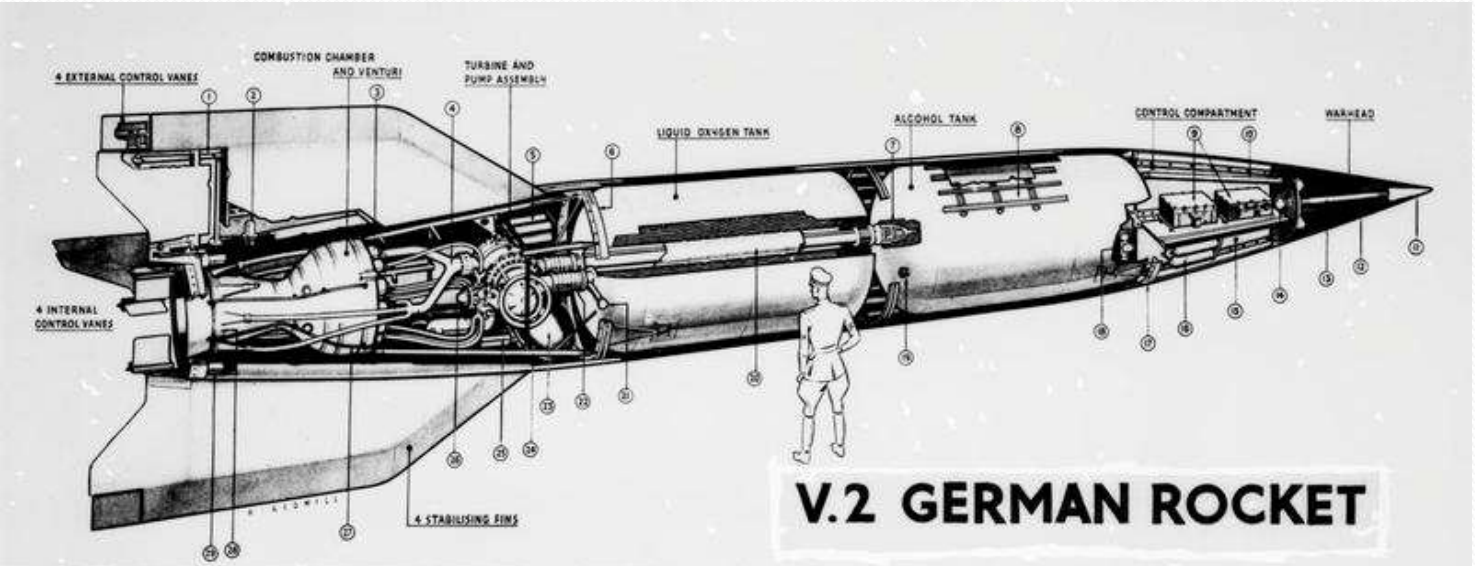


Rudder





Guidance system in V1 Rocket – The Flying Bomb



1 CHAIN DRIVE TO EXTERNAL CONTROL VALVES.

2 ELECTRIC MOTOR.

3 BURNER CUPS.

4 ALCOHOL SUPPLY FROM PUMP.

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Guidance system in V2 Rocket – Vergeltungswaffe

- We have already stated that guidance is that aspect of a missile system which helps it to decide the direction in which the missile should move. Generally this decision has to be taken at very short intervals of time (1/50th of a second) during the flight of the missile.

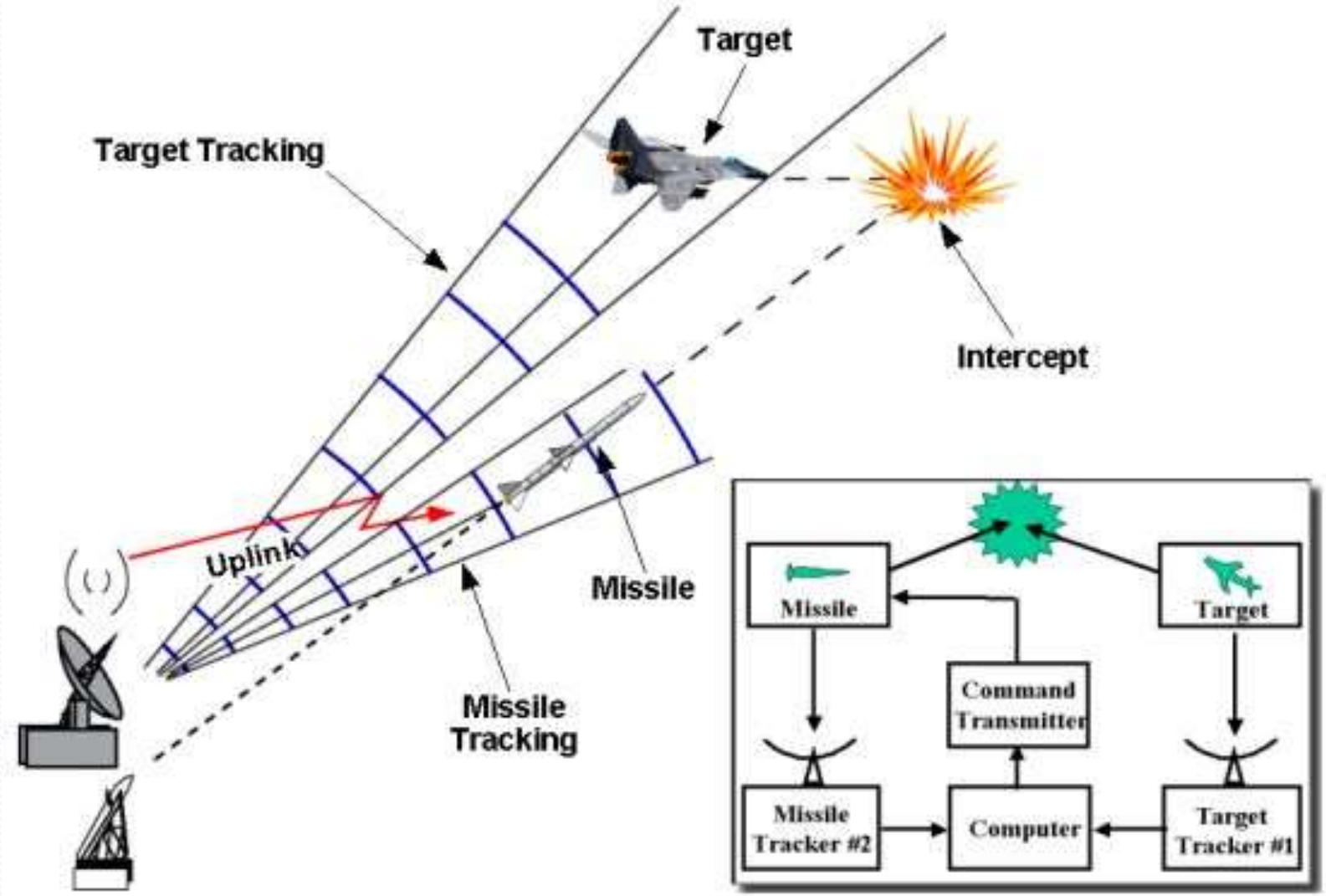
- The different types of guidance :
  Command guidance
  Homing guidance
  Beam rider guidance
  Inertial guidance

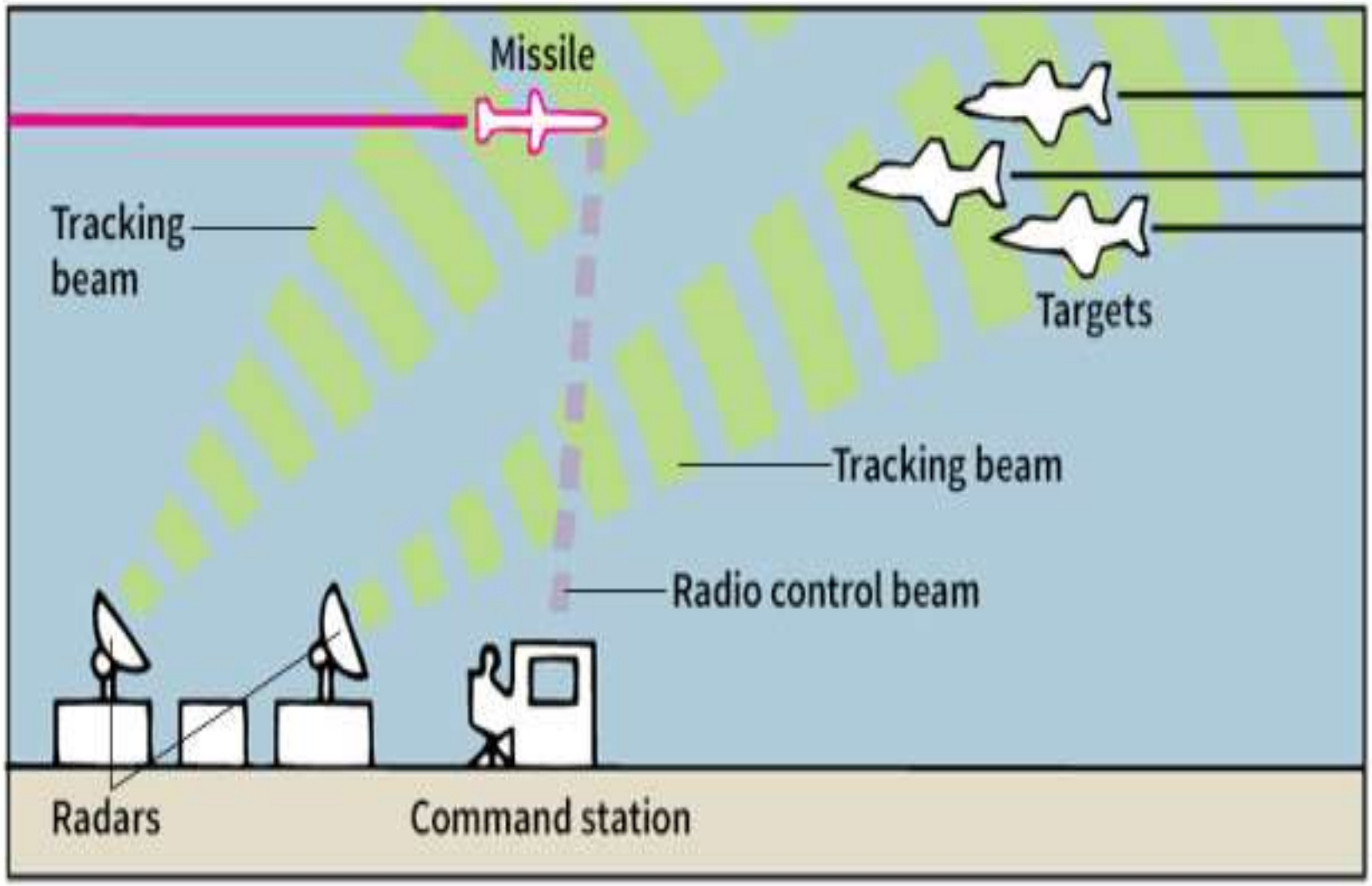
COMMAND GUIDANCE

- In this method, the guidance signal is transmitted from launch site to the missile, giving the missile its deviation from the path line -pointing from launcher to the target, also called the line of sight (LOS).

- The missile has a logic on board to actuate its control mechanism to turn it towards the LOS.

- One method is a wire link between the launcher and the missile and this has been widely applied in surface-to-surface anti-tank missiles up to 4 km range.


Target
Target Tracking
Intercept
Uplink
Missile
Missile
Tracking
Missile
Target
Command
Transmitter
Missile
Tracker #2
Computer
Target
Tracker #1


Missile
Tracking beam
Targets
Tracking beam
Radio control beam
Radars
Command station

- The deviation of the missile from target to launch line of sight is computed on the ground at short intervals (30-50 m/s) and then updated commands are transmitted to the missile.

- To compute errors, instantaneous positions of missile and target are found out. This is done by means of radar, TV or infrared sensors located on the launcher.

- Most of the anti-tank missiles and some of surface-to-air missiles use command guidance.

ADVANTAGE

An important advantage of command guidance systems is that very little guidance equipment need be carried in the missile itself.

Because target tracking and flight path computation are carried out by tracking radars and the associated computers on the ground, the missile need carry only its control system and a receiver to accept the signals.

Reduction in the amount of guidance equipment carried in the missile means more room for a larger warhead.

DISADVANTAGE

The disadvantage of command guidance is that it cannot be used against a situation of multiple targets. The system can guide only a limited number of missiles at one time.

HOMING GUIDANCE

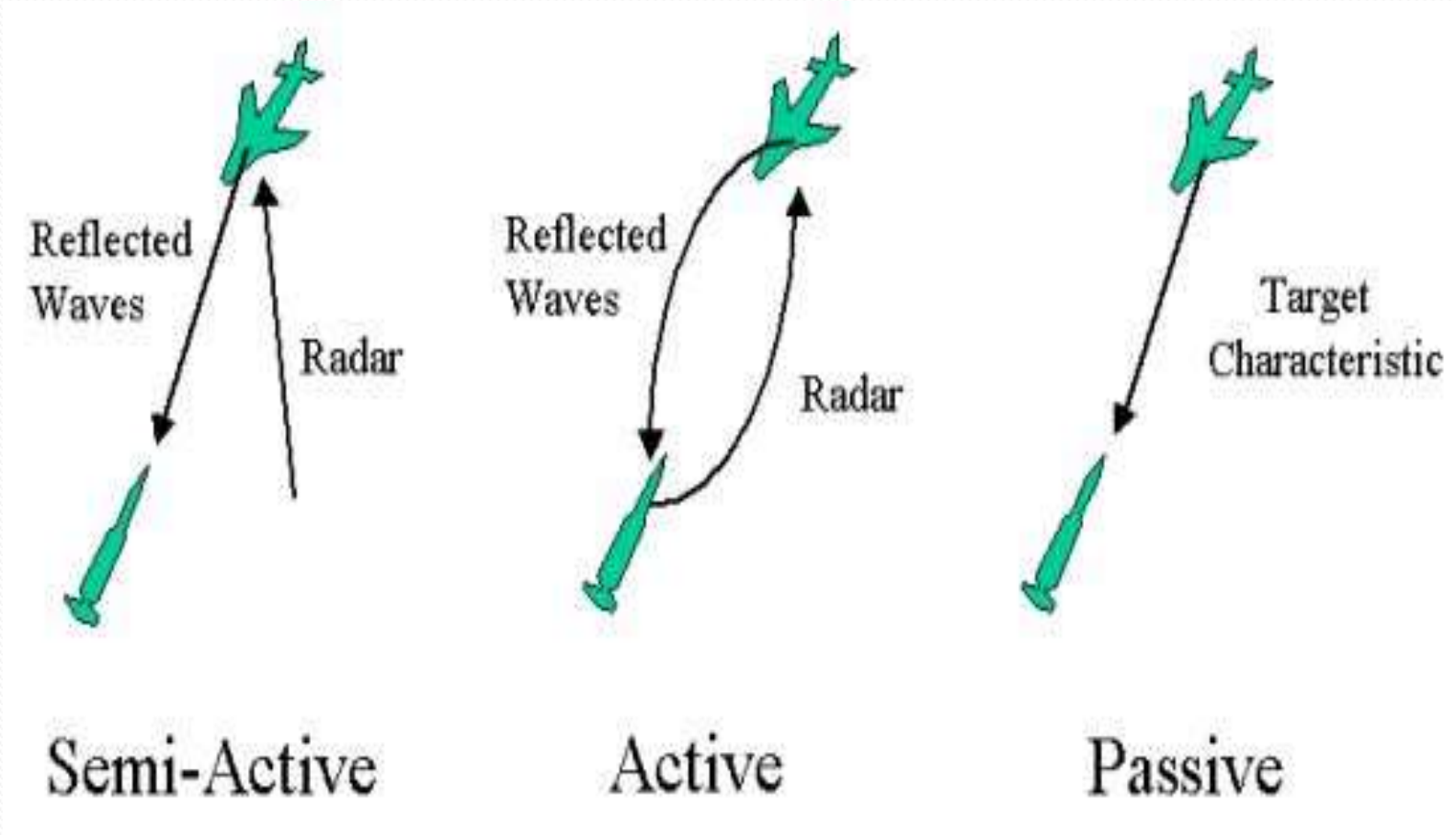
- Homing guidance is generally used for short-range missiles. In this system the missile receives the signals reflected/emanating from the target and generates the command to direct its motion along the instantaneous LOS formed between the missile and the target.

- In homing guidance the missile steers itself towards a target using an onboard seeker which is able to detect some distinguishing characteristics of the target.

TYPES OF HOMING GUIDANCE

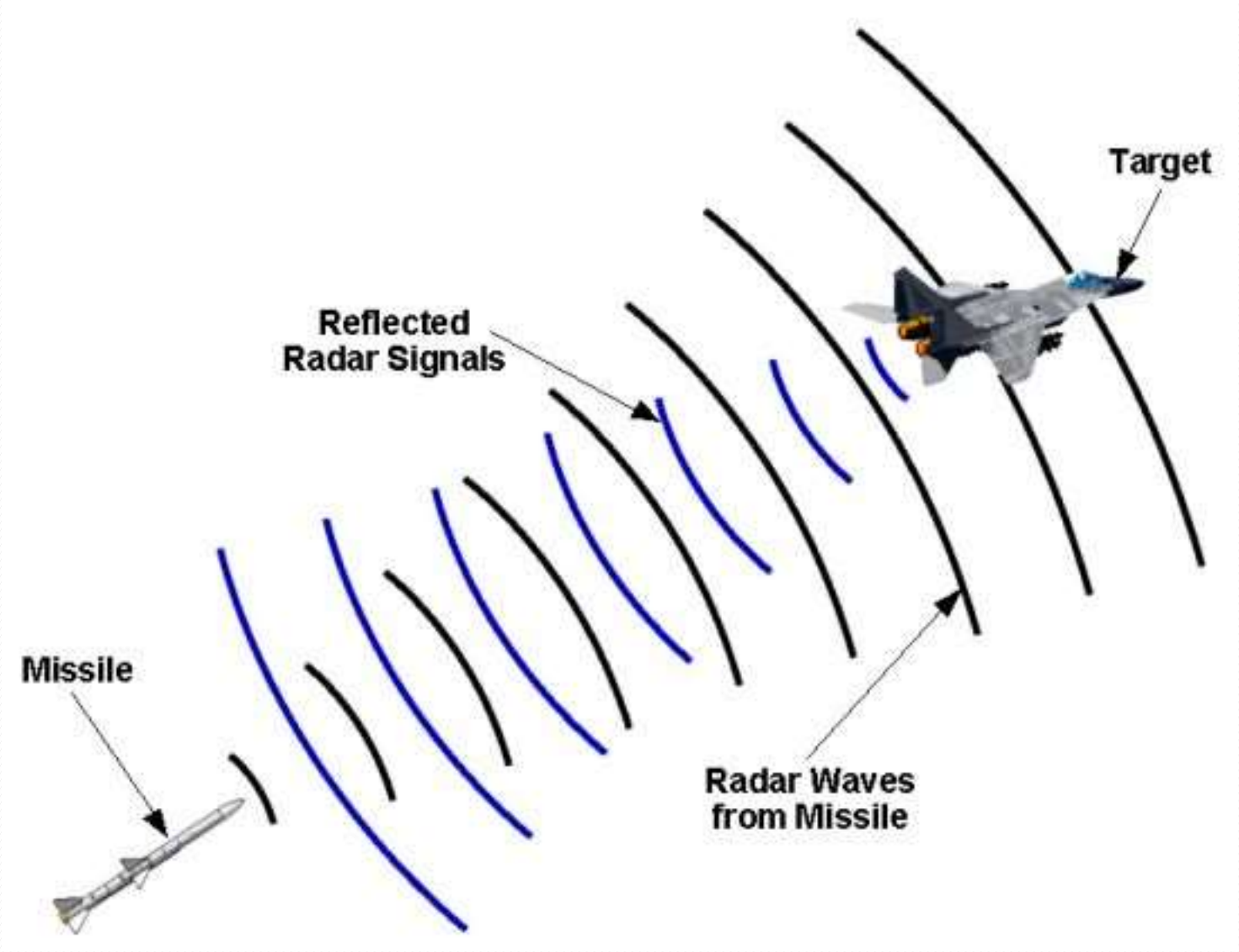
Homing guidance can be divided into three main variant:

- Active Homing
- Semi-Active Homing
- Passive Homing


Reflected
Waves
Radar
Semi-Active
Reflected
Waves
Radar
Active
Target
Characteristic
Passive

ACTIVE HOMING

- In the active homing guidance system, the missile itself carries the transmitter and the receiver. The signal, generally electromagnetic radiation, is transmitted at the target and the reflected signal is received.
- In this system, the missile is not dependent on the ground launcher. Active homing can be used for guidance in all phases, from launch up to target interception. It can also be used in terminal guidance in conjunction with other modes of guidance for the initial phases.

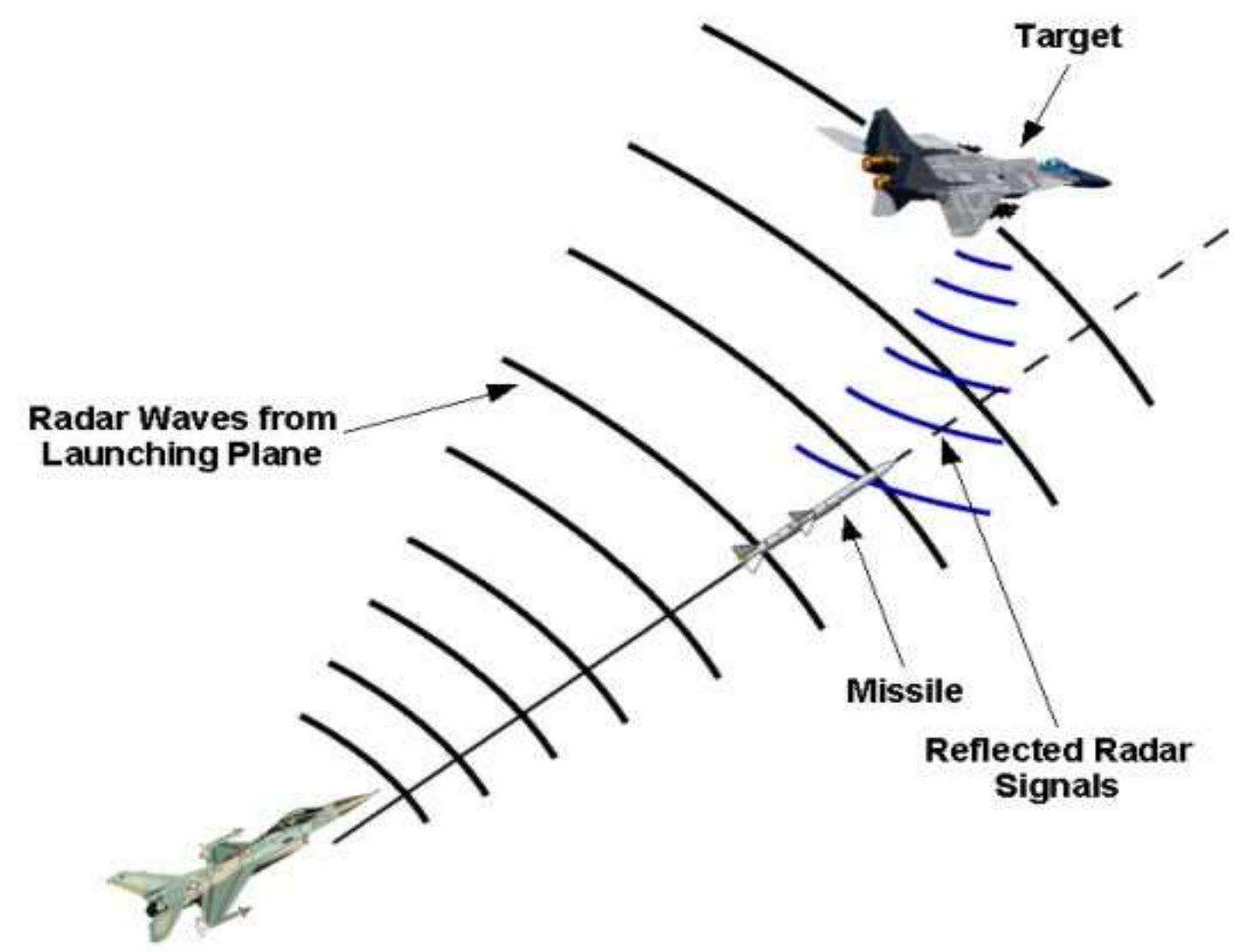

Target
Reflected
Radar Signals
Missile
Radar Waves
from Missile

HARPOON AGM

The **AGM-84D Harpoon** is an all-weather, over-the-horizon, anti-ship missile system produced by Boeing [formerly McDonnell Douglas].
The **Harpoon's** active radar guidance, warhead design, and low-level, sea-skimming cruise trajectory assure high survivability and effectiveness

SEMI-ACTIVE HOMING

- In semi-active guidance, the source for target illumination is located in the launcher and the missile has only the receiver. The rest of the process is identical to active type.
- This type helps to have a simple onboard system and can be used for longer ranges (up to 50 to 60 km). Examples of this are the missiles Seahawk, Sea dart and Sea sparrow.


Target
Radar Waves from
Launching Plane
Missile
Reflected Radar
Signals

BLOOD HOUND SAM

The Bristol Bloodhound is a British surface-to-air missile developed during the 1950s as the UK's main air defense weapon, and was in large-scale service with the Royal Air Force (RAF) and the forces of four other countries.

PASSIVE HOMING

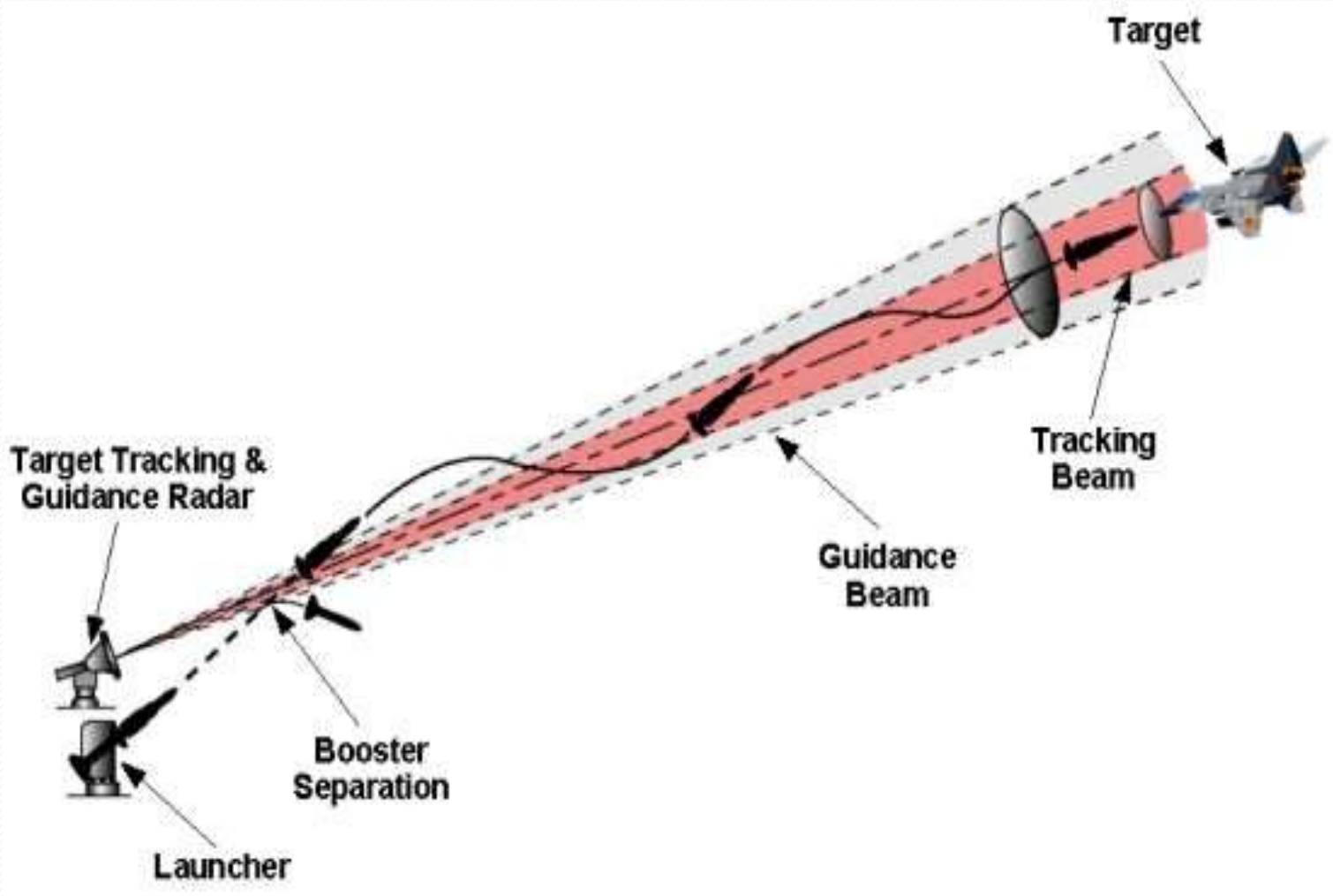
- In passive homing type, the missile has only a receiver and detects signals emanating (not reflected) from the target. The signals could be electromagnetic or infrared or both. 'The missile has in its homing head detectors sensitive to infrared or electromagnetic radiation.
- The missile where infrared homing is used are also called heat-seeking missiles. This system can also be used in conjunction with other modes of guidance in the same way as the active system

MISTRAL SAM

Mistral is an infrared homing surface-to-air missile manufactured by the European multinational company MBDA missile systems (formerly by Matra Bae Dynamics).

BEAM RIDER GUIDANCE

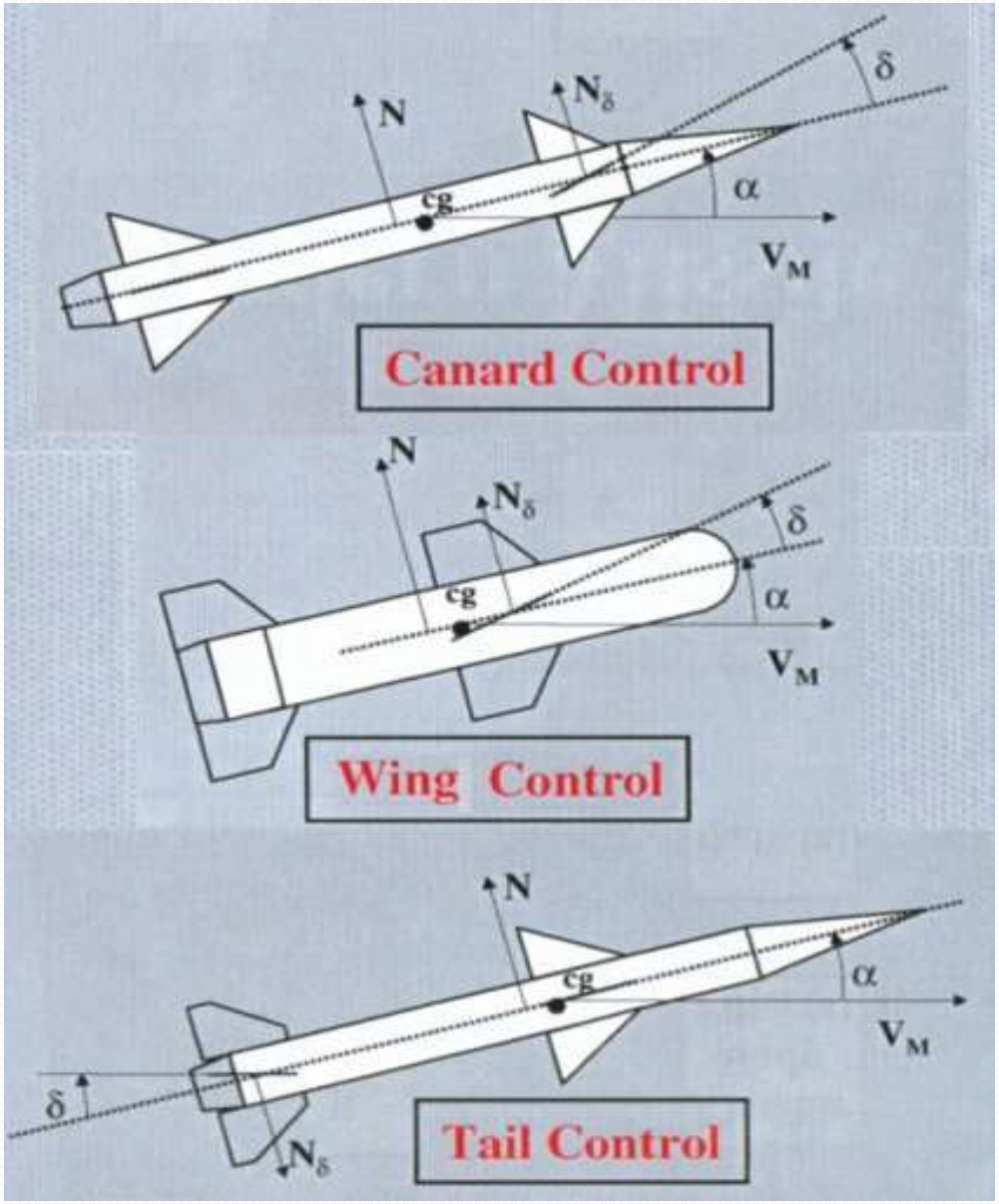
- In this method, the guidance system is to illuminate the target by radiation of a beam of energy from a radar antenna pointed at the target.
- The missile is fired into this beam and thereafter gets guided over the beam till it hits or misses the target.
- In a beam rider guidance system, equipment in the missile measures the displacement of the missile from the Centre of the radar beam then appropriate action by the control system steers the missile back into the Centre of the beam.
- If the missile is flying in the Centre of the beam, no signals are sent to the control system, indicating that no corrective action is necessary.

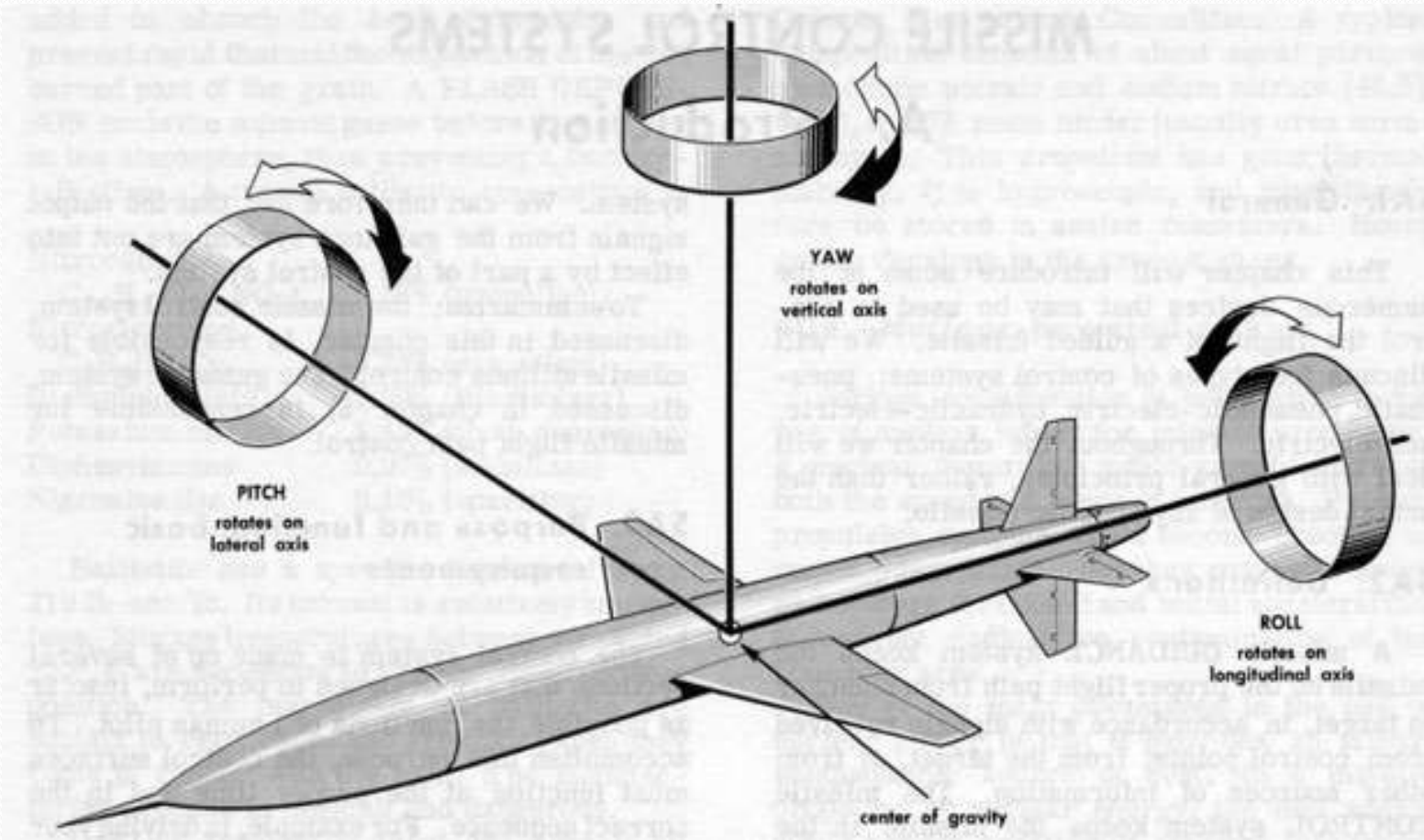

Target
Target Tracking &
Guidance Radar
Tracking
Beam
Guidance
Beam
Booster
Separation
Launcher

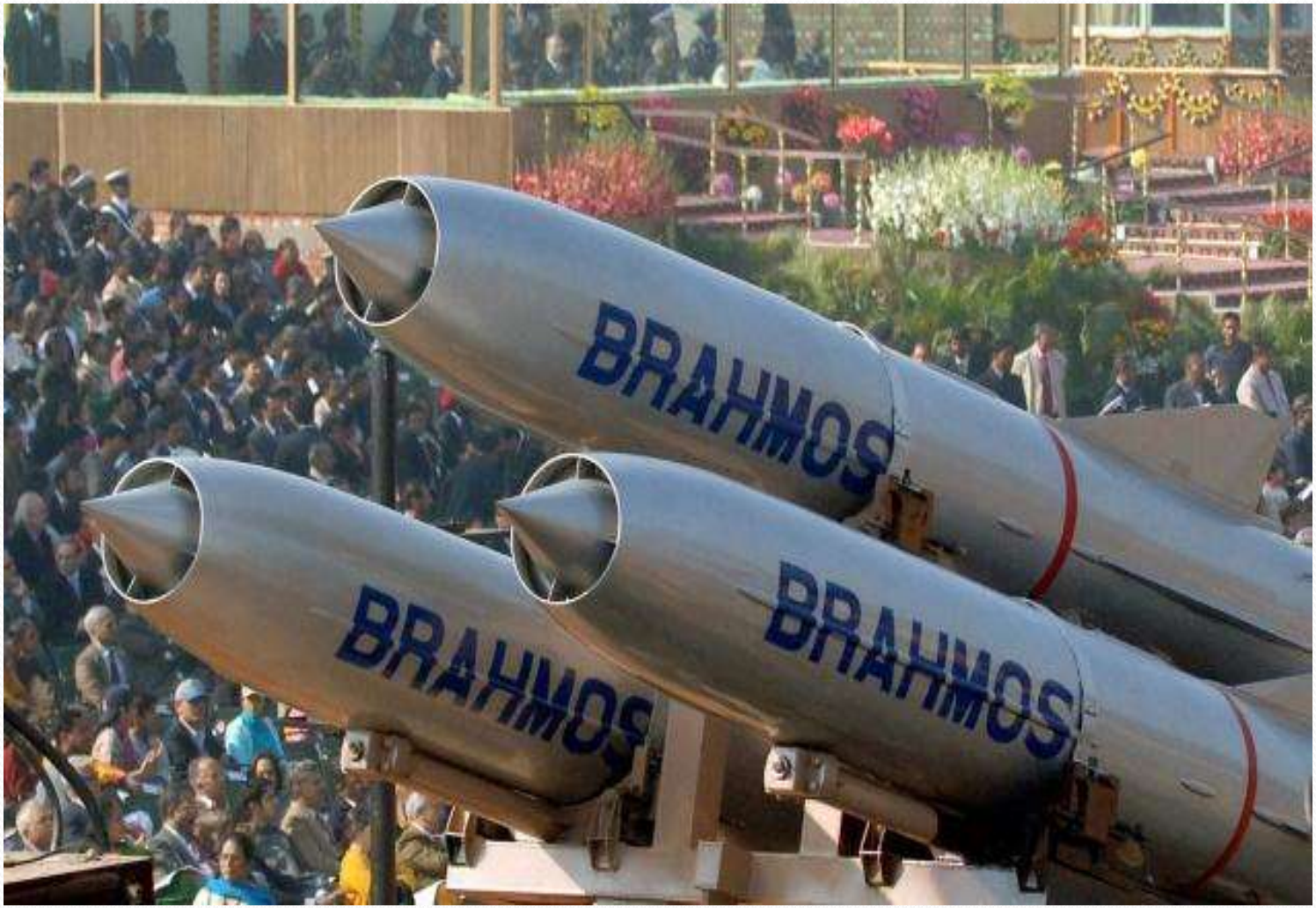
- This type of guidance system is relatively simple, less complex with increased reliability and lower cost. The limitation is that the trajectory requires high lateral acceleration during the terminal phase.

MECHANICAL UNIT

- The unit controlling and guiding the missile on the right track is called as stabilizer fin assembly.
- It could be either fitted on the nose, or middle or the tail.



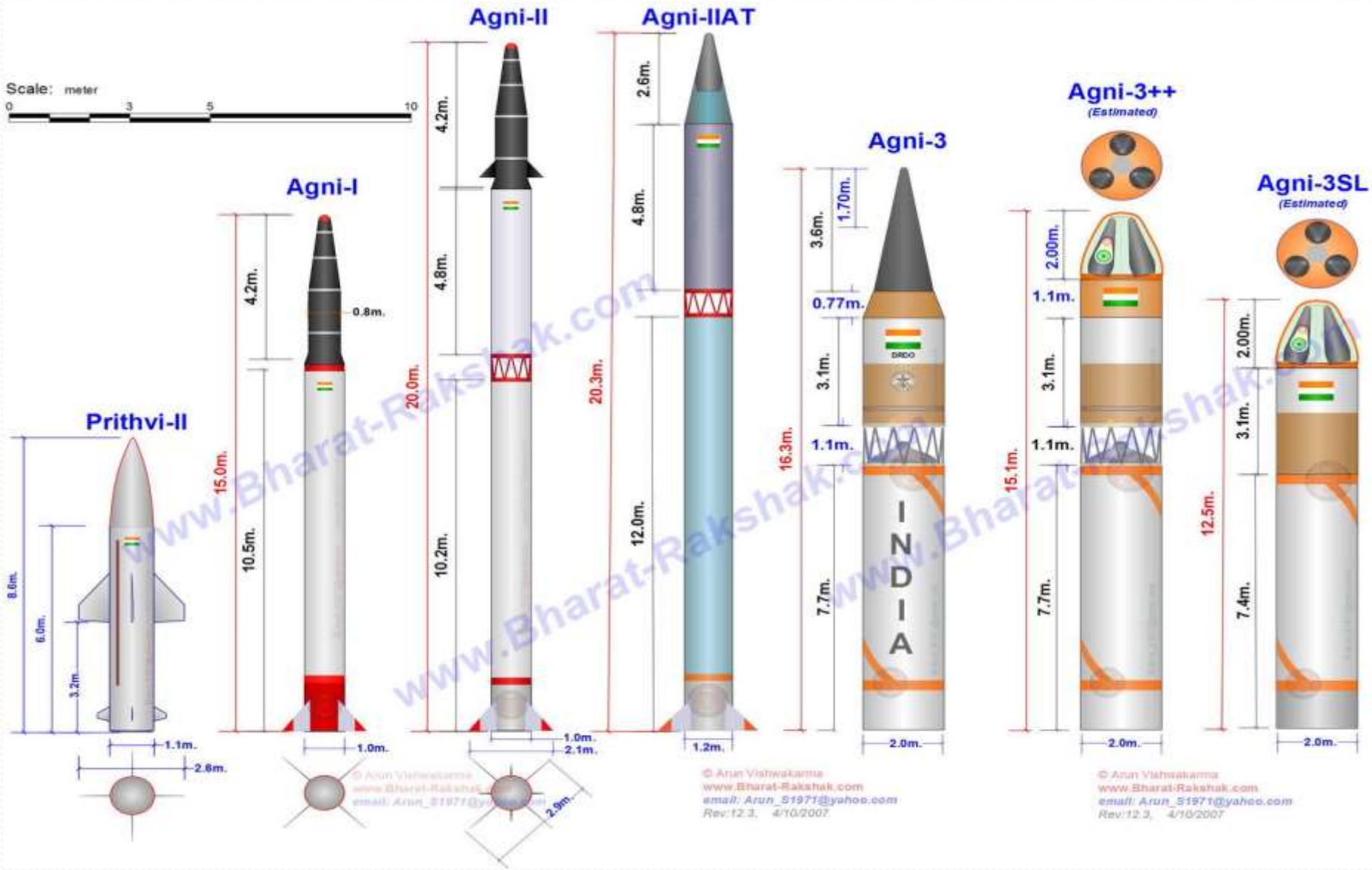

YAW
rotates on
vertical axis
PITCH
rotates on
lateral axis
ROLL
rotates on
longitudinal axis
center of gravity


BRAHMOS
BRAHMOS
BRAHMOS

Medium Range Ballistic Missiles (MRBM)				
Name	**Meaning**	**Range (km)**	**Payload (kg)**	**Status**
Agni-I	Fire	700-1200	1000	Operational
Agni-II	Fire	2000-2500	500-1500	Induction by 2014-15

Intermediate Range Ballistic Missiles (IRBM)				
Name	**Meaning**	**Range (km)**	**Payload (kg)**	**Status**
Agni-III	Fire	3500	2490	Operational

Intercontinental Ballistic Missiles (ICBM)				
Name	**Meaning**	**Range (km)**	**Payload (kg)**	**Status**
Agni-V	Fire	5000-8000	1500+	Induction by 2014-15
Agni-VI	Fire	6000-10000	700-1400	Under development


Scale: meter
0
3
5
10
Prithvi-II
8.6m.
6.0m.
3.2m.
1.1m.
2.8m.
Agni-I
15.0m.
4.2m.
10.5m.
0.8m.
1.0m.
Agni-II
20.0m.
4.2m.
4.8m.
10.2m.
1.0m.
2.1m.
2.9m.
Agni-IIAT
20.3m.
2.6m.
4.8m.
12.0m.
1.2m.
Agni-3
16.3m.
3.6m.
1.70m.
0.77m.
3.1m.
1.1m.
7.7m.
DRDO
INDIA
2.0m.
Agni-3++
(Estimated)
15.1m.
2.00m.
1.1m.
3.1m.
1.1m.
7.7m.
2.0m.
Agni-3SL
(Estimated)
12.5m.
2.00m.
3.1m.
7.4m.
2.0m.
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Tarmak007
NGL-02

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THANK YOU